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WATER QUALITY CONTROL STUDY, LOWER MUSSELSHELL UNIT, MONTANA

Federal Water Pollution Control Administration
Kansas City, Missouri

September 1966

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WATER QUALITY CONTROL STUDY
LOWER MUSSELSHELL UNIT
MONTANA

Study of Potential Needs & Value of Water for the Purpose of Water Quality Control of the Lower Musselshell Unit, Montana

LOCATION MAP

UNITED STATES
DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Kansas City, Missouri
September 1966

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FWPCA Kansas City, Missouri Sept. 1966

Prepared at the request of and in cooperation with the Bureau of Reclamation, Region 6 Dept. of Interior Billings, Montana

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WATER QUALITY CONTROL STUDY

LOWER MUSSELSHELL UNIT

MONTANA

ABSTRACT

A survey has been made of the Musselshell River Basin and the Lower Musselshell Unit in particular which determined that waters of the area are highly mineralized. Waters stored in the proposed reservoir would not be of a sufficiently better mineral quality to improve water in the project area; and therefore, storage for water quality control has not been recommended.

Prepared at the request of and in cooperation with the
Bureau of Reclamation, Region 6
Department of the Interior
Billings, Montana

United States Department of the Interior
Federal Water Pollution Control Administration
Kansas City, Missouri

September 1966

I-a

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I. INTRODUCTION

Request and Authority

The Bureau of Reclamation, Region 6, Department of the Interior, in a memorandum dated March 12, 1965, requested the Public Health Service, U. S. Department of Health, Education, and Welfare* to provide a water quality control study of the proposed Lower Musselshell Unit, Musselshell Division, Missouri River Basin Project. This is in accord with the Water Pollution Control Act, as amended (33 U.S.C. 466 et seq).

Purpose and Scope

The general objectives of this study are to assess the effects of project construction and operation on the water quality in streams and reservoirs in Garfield and Petroleum Counties in east-central Montana: (1) to ascertain what benefits are achieved or lost from changes in water quality; (2) to assess the suitability of the water for its proposed uses; and (3) to examine the need for streamflow regulation for the purpose of water quality control. The necessity of streamflow regulation was studied not only in light of present conditions but also for anticipated future conditions in the study area to the year 2070.

The conclusions presented must be considered tentative pending completion of the Missouri-Souris-Red River Basins Comprehensive Water Supply and Water Quality Management Study being conducted in this region by the Federal Water Pollution Control Administration. The results provided herein are suitable for project feasibility determinations.

Acknowledgements

The assistance and cooperation of State and Federal Agencies and individuals are gratefully acknowledged. Particular recognition is expressed to the following for data and advice furnished by their staff members:

*Responsibility for these activities has been transferred from the Department of Health, Education and Welfare to the Department of the Interior in accordance with Reorganization Plan No. 2, effective May 10, 1966.

U. S. Bureau of Reclamation, Region 6
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and
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Geological Survey, Water Resources Division
Branch of Quality of Water
Worland, Wyoming

Fish and Wildlife Service
Bureau of Sport Fisheries and Wildlife
Missouri River Basin Studies
Billings, Montana

Montana Bureau of Mines and Geology
Montana School of Mines
Butte, Montana

Montana State Health Department
Helena, Montana

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Bureau of Reclamation, Region 6, in connection with its Missouri River Basin Project, Musselshell River Basin, is considering the construction of a dam and reservoir on Flatwillow Creek, a tributary of the Musselshell River. The dam site will be located about one and one-half mile upstream from the confluence of Flatwillow Creek and the Musselshell River.

2. This study covers the entire Musselshell River Basin, however, special emphasis has been placed on that portion of the basin located in Garfield and Petroleum Counties. The Lower Musselshell Unit is located along the eastern boundary of Petroleum County and along the western boundary of Garfield Coutny. The economic evaluation for this study was, therefore, limited to the above-named counties only.

3. The economy of the area is highly specialized in the raising of range livestock which utilizes the area's major resource, extensive grazing lands. It is a relatively isolated and uninhabited area with less than one person per two square mile, and the population is declining. There do not appear to be exploitable resources or other forces which could work to change the pattern of activity or the trend in population here.

4. Irrigation is the major use of water of the Musselshell River at present. It will also represent the major use of project water. Communities and individuals of the area rely on ground-water sources for domestic supplies.

5. There are no sources of municipal or industrial pollution (other than agricultural) in the Musselshell River Basin which would affect water quality. Available information on water quality in the study area shows the following ranges in specific conductances and TDS[a] concentrations.

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[a] TDS consists mainly of carbonates, bicarbonates, chlorides, sulfates, phosphates, and possible nitrates of calcium, magnesium, sodium, and potassium. (4) In this report the TDS and salt content are considered to be approximately the same.

Station	Range of Specific Conductance umho/cm @ 25° C	Range of TDS Concentration mg/l (milligrams per liter)
Musselshell River above mouth of Flatwillow Creek (11/8/62-9/30/65)	599-3930	391-3200
Flatwillow Creek just above its mouth (3/11/63-9/30/65)	916-4530	639-4180

6. There are approximately 28,000 acres presently irrigated from Flatwillow Creek above the proposed reservoir site and 75,000 acres presently irrigated from the Musselshell River above Mosby, Montana. The proposed Lower Musselshell Unit will provide water for irrigation of approximately 8,000 acres of land located in a narrow strip along both sides of the Musselshell River from the mouth of Flatwillow Creek to the maximum water level of Fort Peck Reservoir, a distance of 30 miles. An annual average of 3 acre-feet/acre or approximately 24,000 acre-feet will be applied to the irrigated land; however, the amount applied and/or the acreage irrigated will be varied depending on the availability of water. Where there is a number of low flow years in succession, the acreage irrigated will be decreased. Shortages occur in 5 out of 36 years of operation.

7. The Fish and Wildlife Service has recommended an instantaneous release of 15 cfs from Flatwillow Reservoir to help prevent the occurrence of low flows in the Musselshell River during non-irrigation and for the purpose of developing and maintaining a fishery in the one and one-half mile reach of Flatwillow Creek between the reservoir and the mouth.

Conclusions

1. The economic study indicates no change from the present pattern of activity or in the population trend.

2. After project construction, the average flow during irrigation season in the Musselshell River just below the mouth of Flatwillow Creek will be 109,000 acre-feet, an increase of 6,000 acre-feet

over historic conditions. The average irrigation demands of 44,000 acre-feet will be met from this flow. Assuming that 40 percent of the irrigation demand returns to the river during the year and that 65 percent of the total return occurs during irrigation season, then the depletion in flow (under average conditions) of the Musselshell River between the upper and lower ends of the unit is 17,760 acre-feet. The average flow during irrigation season at the lower end of the unit, neglecting any other accretions, will be 91,200 acre-feet.

3. The flow weighted mean TDS in mg/l of the Musselshell River, just below the mouth of Flatwillow Creek, during the irrigation season will be about 1,000 mg/l with expected maximums near 2,500 mg/l and lows near 700 mg/l. Based on the historical record of 31 years, the percentage of the time that flow weighted mean TDS concentrations for an irrigation season will fall within a given range is as follows:

Range of TDS Concentration mg/l	Percentage of Time that Concentration is Within Given Range
0-1000	39%
1010-1500	39%
1510-2000	20%
Over 2000	2%

The reservoir will provide a more dependable flow for irrigation during the months May through September. There will be a tendency for salt concentrations to increase in the reservoir during the years of low flow when the inflows to the reservoir are generally high in TDS. Evaporation will further increase these concentrations. High inflows of better quality water during the late spring and early summer months of some years should dilute down or completely displace the reservoir contents.

4. From an analysis of past records it is projected that during 6 to 8 irrigation seasons of the 31 years of record studied, the TDS concentrations in the downstream reaches of the project are expected to exceed 3150 mg/l[a]--the number of times this value is exceeded will

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a/ Generally set as the upper limit of TDS concentration for the safe watering of any plant providing adequate leaching and drainage are furnished.

depend on the low flow condition and the amount of salt pickup; i.e., if a 1:1 salt balance is maintained, 3150 mg/l would be exceeded 6 times, if there is a 2 ton/acre pickup of salt per year it would be exceeded 8 times. During 4 additional years with a 1:1 salt balance maintained or 6 additional years with a 2 ton salt pickup per acre the TDS concentration in the lower reaches is expected to exceed 2150 mg/l[a/] but be less than 3150 mg/l. It would require about 10,000 acre-feet of additional water for water quality control for agricultural purposes within the project area during critical years. During high runoff years, excess water would be availabe for storage for subsequent use in water quality control. With as many as 4 critical years occurring between periods of high runoff, it would be necessary to have a total draft on storage of about 40,000 acre-feet in order to meet water quality control requirements. An alternative would be to reduce the amount of irrigated acreage during the low flow years so sufficient water can be applied to provide adequate leaching for the remaining acreage.

5. The Musselshell River empties into a large body of water--Fort Peck Reservoir. The average monthly flows from the river constitute, generally, less than 0.2% of the average monthly contents of the reservoir. This unique situation (for a plains area) precludes significant adverse effects to water users below the project; thus, the inclusion of storage in the Flatwillow Creek Reservoir for the purpose of water quality control below the project is not necessary.

6. The conclusions presented are based on various assumptions and the results of other studies. The lack of data on water quality and flows below Mosby, Montana, precludes a more accurate analysis of project effects on water quality. The results provided herein are suitable for use in project feasibility studies. The completion of the Missouri-Souris-Red River Basins Comprehensive Water Supply and Water Quality Management Study being conducted in this region by the Federal Water Pollution Control Administration may provide additional or other conclusions.

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a/ Water containing up to 2,150 mg/l is considered suitable for the crops that will be grown in the area.

III. PROJECT DESCRIPTION

The Lower Musselshell Unit, Musselshell Division, Missouri River Basin Project, is located in the Musselshell River Basin in east-central Montana. Project water will be derived from a drainage area of 1,855 square miles. The proposed project area lies in portions of Petroleum and Garfield Counties and drains into the Fort Peck Reservoir located at the extreme lower end of the Lower Musselshell Unit.

The proposed dam and reservoir site is on Flatwillow Creek about one and one-half mile upstream from its confluence with the Musselshel River (1). The total capacity of the proposed Flatwillow Reservoir is 70,819 acre-feet of which: 23,062 acre-feet will be dead and inactive storage consisting of 12,000 acre-feet based on an estimated 100-year sediment accumulation and 11,062 acre-feet will be inactive storage to meet the tentative requirements for fish, wildlife, and recretational purposes. The remaining 47,757 acre-feet will meet the conservation requirements (2,3,4).

The proposed project will provide irrigation water for approximately 8,000 acres of land located in a narrow strip along both sides of the Musselshell River from the mouth of Flatwillow Creek to the maximum water level at Fort Peck Reservoir, a distance of 30 miles. A portion of this 8,000 acres is presently irrigated but in some years does not receive an adequate supply of water, and thus, crop failure is common. Irrigation water will be furnished to project lands by privately constructed and operated pumping plants and associated distribution systems. The tracts to be irrigated under this project are generally less than 300 acres and lie less than 30 feet above the Musselshell River (5). On completion, Flatwillow Reservoir will inundate about 5-6 miles of Flatwillow Creek.

The Fish and Wildlife Service has recommended a minimum instantaneous release of 15 cfs from Flatwillow Reservoir to help prevent the occurrence of low flows in the Musselshell River during the non-irrigation season. This would enable the development of a fishery of about one and one-half miles of Flatwillow Creek between the reservoir and the mouth. Estimated fishing benefits from this would be $1,800.00 annually. The total benefits to fisherman from project construction is evaluated at $9,800.00 annually (5).

IV. STUDY AREA DESCRIPTION

The entire Musselshell River Basin was considered for this study with specific emphasis given to the Lower Basin in Petroleum and Garfield Counties in east-central Montana. (See Figure 2, at back of report.) The North Fork and the South Fork of the Musselshell River rise in the Little Belt Mountains and the Crazy Mountains, respectively. They meet about 25 miles west of Harlowton to form the main stem of the Musselshell River which then flows east to Melstone, then north, and empties into the Missouri River at the upper end of Fort Peck Reservoir. Flatwillow Creek rises in the Big Snowy Mountains north of Ryegate, flows in an easterly direction, and empties into the Musselshell River about 6 miles above Mosby. The Musselshell River Basin drainage area above Mosby contains 7,846 square miles, of which 1,855 square miles drain to Flatwillow Creek. Elevations in the drainage area decrease from about 10,000 feet in the mountain regions to 2,500 feet in the plains area (elevation at Mosby is approximately 2,500 feet above mean sea level).

The area is range land of varying quality with irrigation common along Flatwillow Creek and along the Musselshell River. An estimated 28,000 acres is irrigated from Flatwillow Creek above its mouth; approximately 75,000 acres are being irrigated along the Musselshell River and its tributaries above the mouth of Flatwillow Creek (6). About 2,800 acres have been irrigated periodically below the mouth of Flatwillow Creek (5).

The climatological characteristics are those of a semiarid region with an average rainfall of approximately 14 inches, much of which is in the form of torrential downpour during the growing season. Temperatures in this area are exceedingly variable. Extremes of -50° F and 110° F have been recorded. The mean annual temperature in east-central Montana is 43° F (7,8).

There are no towns located in the project area. Winnett (population 360) is located on McDonald Creek approximately 35 river miles upstream of the Flatwillow site. Mosby (population 5) is located below the confluence of Flatwillow Creek, but it cannot be considered a town.

The major industry in this area is livestock raising. There are some oil wells located along Cat Creek, a tributary, which enters the Musselshell River about 5 miles below Mosby. No flow or water quality data is available on this tributary.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

In the Musselshell River Basin, streamflows at the higher elevations are derived from springs and snowmelt; in the plains area, the tributaries flow intermittently and are characterized by high spring runoffs and variable summer flows due to rains. The low flow period usually extends from the late summer months through February. Table I presents average streamflows for selected stations in the Basin. The maximum flows given are instantaneous flows and all but the maximum flow recorded for the Boxelder Creek station occurred in the month of June.

Groundwater is not an adequate source of supply for irrigation water; however, this source is used as a municipal supply for towns located in the Musselshell River Basin. It is also used as a source for stock watering and as an individual domestic supply for rural areas. In the upper portion of the basin, the water supply usually comes from shallow wells; in the lower portion, the supply comes from shallow wells generally located adjacent to the river or from deep artesian wells (11).

Quality of Water Available

Surface waters of the study area are at times highly mineralized especially at low stream flow; the quality becomes better at high stream flows.

Chemical analyses of surface waters in the project area show high concentration of TDS, sulfates, bicarbonates, calcium, magnesium, and sodium (Table II). The principal causes of salinity in the stream are the groundwater draining saliferous shales and the salt load contributed by irrigation return flows. During a recent field investigation of the project area, large alkali outcroppings were noted along the river banks and the surrounding terrain.

The groundwater sources used for municipal supplies in the Musselshell River Basin are adequate in quality except for the 2,000 foot artesian well at Winnett, which has a high sulfate content (11). Water of a highly mineralized nature (1,000-3,000 ppm TDS) is found in the project area at depths of less than 500 feet. In these waters, sodium and sulfate are the main chemical constituents (13).

TABLE I

Streamflow Records for Selected Stations
Musselshell River Basin*

Station	Period of Record	Flows			
		Max. (cfs)	Min. (cfs)	Avg. (cfs)	Avg. Annual (1000 ac-ft.)
Musselshell River					
at Harlowton	Oct 1934-Sept 1964	4,160	0	131	94.7
at Ryegate	Oct 1946-Sept 1964	6,260	0	154	111.3
at Roundup	Oct 1946-Sept 1964	7,460	0.6	172	124.3
near Mosby (above Flatwillow Creek Confluence)	Oct 1962-Sept 1964	3,050	5	138	99.7
at Mosby	Oct 1934-Sept 1964	18,000	0	227	164.0
McDonald Creek					
at Winnet	Oct 1934-Sept 1945 Oct 1953-Sept 1956	900	0	31	22.4
Boxelder Creek					
near Winnet	Oct 1959-Sept 1964	9,910	0	22	15.9
Flatwillow Creek					
near Winnet	Oct 1921-Sept 1929 Oct 1948-Sept 1951	3,770	0	44	31.8
at proposed site	Oct 1925-Sept 1961c/	-	0	41	29.6

a/ See Figure 1 for location of gaging stations.
b/ Flow is the instantaneous maximum.
c/ Data from Bureau of Reclamation Operation Study (2).
*Source: USGS Data (5,9,10).

TABLE II

Chemical Quality of Surface Waters
Musselshell River Basin[a/]

Description of Station	Period of Record	[b/] Range	Est. Flow CFS	25°C Umho	TDS[b/] mg/l	pH	SAR[d/]	Water Temp Deg. F	Ca mg/l	Mg mg/l	Na mg/l	HCO_3 mg/l	SO_4 mg/l	Cl mg/l
Musselshell River just above the mouth of Flatwillow Creek	11/8/62 thru 9/30/65	Max.	1495	3870	3200	8.2	6.5	84	216	175	530	500	1900	46
		Min.	9.2	599	391	6.5	1.9	32	37	15	60	103	190	5.0
		WM	185	1370	1010	-	-	-	91	52	149	259	509	13
Flatwillow Creek just above its mouth	3/11/64 thru 9/30/65	Max.	1689	4530	4180	8.4	7.9	84	249	186	670	417	2400	42
		Min.	1.7	916	639	7.1	1.5	32	72	33	72	152	336	4.5
		WM	135	1420	1110	-	-	-	117	61	127	223	589	7.1

a/ Data from U.S. Department of the Interior, Geological Survey, Worland, Wyoming (12)
b/ The maximum and minimum values are given only to indicate the variation in water quality over the sampling period. The flow weighted mean is given for chemical constituents; the time-weighted mean is given for flow.
c/ Milligrams per liter
d/ Sodium absorption ratio (15)

VI. THE ECONOMY

This area is part of the extensive, high plains area of central Montana. It is a semiarid grassland, level and gently rolling with breaks and bluffs along the river and washes.

The portion of the Musselshell River along which lands affected by this project lie forms the boundary between Garfield and Petroleum Counties. The river flows north into the Fort Peck Reservoir which is the northern boundary of these two counties. These two counties form the area of this economic study. The major resource of the area is its extensive grazing lands. In utilizing this resource, the economy of the area has become highly specialized in the raising of range livestock. Much more specialized, in fact, than the State of Montana which is itself primarily agricultural. This narrow base of economic activity limits the development potential of the area.

Present Economic Activities

One measure of the dominance of agriculture is the proportion of the labor force so employed. In 1960, 60 percent of the working force of the study area worked at agricultural jobs. This amounted to 710 men. This was a concentration in this industry more than three times greater than in the State of Montana (17.7 percent of the labor force in agriculture) and nearly nine times greater than for the United States (6.7 percent). This portion of the work force in agriculture in the area has remained fairly constant over the past twenty years as can be seen in Table IV. Table III compares the share of employment by major sector in the study area with that in the State of Montana and the United States.

TABLE III

Employment by Selected Industry
Comparison of Study Area,
Montana, United States
1960

	Study Area	Montana	United States
Agriculture	59.8	17.7	6.7
Mining	0.3	2.9	1.0
Construction	3.9	6.4	5.9
Manufacturing	1.8	10.1	27.1
Trade	7.3	20.3	18.2
Services	15.5	22.1	20.9

Source: U.S. Census of Population, 1960

TABLE IV

Employment by Sector
Study Area (Garfield and Petroleum Counties)
1940, 1950, 1960

	1940		1950		1960	
	Number Employed	% of Total	Number Employed	% of Total	Number Employed	% of Total
Primary Industries	942	61.4	933	66.6	714	60.1
Agriculture	910	59.3	880	62.8	710	59.8
Extractive	32	2.1	53	3.8	4	0.3
Secondary Industries	35	2.2	44	3.2	68	5.7
Manufacturing	6	0.3	11	0.8	22	1.8
Construction	29	1.9	33	2.4	46	3.9
Trade Sectors	89	5.8	125	9.0	93	7.8
Wholesale	3	0.2	5	0.4	4	0.3
Retail	86	5.6	120	8.6	89	7.5
Semi-Public	18	1.1	29	2.2	22	1.8
Transportation	13	0.8	24	1.7	10	0.8
Communication & Public Utils.	5	0.3	5	0.5	12	1.0
Private Service	72	4.7	77	5.4	111	9.3
F.I.R.E. (a)	4	0.3	7	0.5	7	0.6
Business & Repair	16	1.0	23	1.6	24	2.0
Personal	30	2.0	21	1.5	53	4.4
Professional (b) (d)	2	0.1	6	0.4	0	0
Other (c) (d)	20	1.3	20	1.4	27	2.3
Government Services	84	5.5	129	9.2	139	11.7
Educational (d)	67	4.4	71	5.0	80	6.7
Public Adminis.	17	1.1	58	4.2	59	5.0
Industry not reported	4	0.3	8	0.5	0	0
Total Labor Force	1532		1400		1187	

(a) Finance, insurance, and real estate
(b) Primarily medical services
(c) Includes entertainment & recreation, hospital, welfare, and other non-profit
(d) Estimated for 1940

Source: U. S. Census of Population

Only four percent of the land in farms in the area is harvested cropland. A little more than one-third of one percent (14,000 acres) is irrigated. One-half of this harvested cropland is hay which is a much higher concentration in hay crops than of the average farms throughout the state. This simply emphasizes the fact that this is a livestock grazing economy. Seventy-eight percent of the farms here are classified as livestock farms. The increase in value of farm products sold during the decade of the 1950's was greater in the study area than for the State of Montana. Livestock and livestock products constituted 90 percent of the total value of farm products sold by the area.

An annual petroleum production of less than 150,000 barrels (in Western Garfield County) is the only mineral production in the county. This employs only one-third of one percent of the labor force and is about one-tenth the value of agricultural production. The proportion of employment in manufacturing and trade and services is very low, and declining. The general level of welfare of the area as measured by income is reasonably good as the following data from a study on income by Montana State University (20) indicates.

TABLE V

Per Capita Income
As a Percentage of U. S. Per Capita Income

	1939	1951	1956	1964(1)
Montana	94.4	107.4	95.0	90.0
Garfield	66.7	172.0	115.5	70.0
Petroleum	96.4	217.2	119.8	117.5

TABLE VI

Per Capita Income & Rank in State (of 56 Counties)
(in dollars)

	1939		1951		1956		1964	
	Income	Rank	Income	Rank	Income	Rank	Income	Rank
Montana	525		1,771		1,877		2,004	
Garfield	381	51	2,837	5	2,281	10	1,558	43
Petroleum	536	17	3,581	1	2,366	6	2,615	1
U.S.	556		1,649		1,975		2,225	

(1) 1964 estimates are from a different source

The relatively greater prosperity of Petroleum County reflects its smaller proportion of rural farm population and higher proportion of non-agricultural employment. Petroleum County also has four times as much irrigated farm land as Garfield.

The area is somewhat isolated with no U.S. highways or railroads traversing it, although there is a hard surface all-weather state road.

Population Trend

This is a thinly populated area. The population density is less than one person for every two square miles of area. The following table shows how empty this part of the country really is.

TABLE VII

Population Density
(Per Sq. Mile)

	1930	1940	1950	1960
Garfield Co.	0.92	0.57	0.47	0.43
Petroleum Co.	1.24	0.66	0.62	0.54
Montana	3.69	3.84	4.06	4.63
United States	34.7	37.2	42.6	50.5

Not only are there few people here, but the number has been steadily decreasing for thirty years or more.

TABLE VIII

Population Trend

	1930	1940	1950	1960	Percentage Change 30-40	40-50	50-60
Garfield Co.	4,252	2,642	2,172	1,981	-38	-18	-30
Jordan (Town)	-	-	696	557			
Petroleum Co.	2,045	1,083	1,026	894	-47	- 5	-18
Winnet (Town)	408	399	407	360			
Study Area	6,297	3,724	3,198	2,875	-41	-14	-10
Montana					+ 4	+ 6	+14
United States					+ 7	+14	+18

The number of people living close enough to the proposed project lands to be affected thereby is much smaller than the above table indicates, being perhaps 10-15 percent of the study area population.

There are no present indications of resources present or social forces at work that will change this trend in the future. Future population in the study area may be expected to look something like the following table.

TABLE IX

Future Population Trend

1970	1980	1990	2000	2020	2040	2070
2640	2480	2380	2340	2100	2000	2000

The population is entirely rural, and, as the 1960 census showed, mostly rural farm.

TABLE X

Percentage of Population, Rural Farm and Rural Non-Farm

	Rural Farm	Rural Non-Farm
Garfield	61.5%	38.5%
Petroleum	54.8%	45.2%
Montana	16.6%	34.2%

There has been no marked increase in the percentage of rural non-farm (small town) population since 1950.

Future Economic Activities

This area will continue to be a narrowly specialized range livestock economy with very few opportunities for diversification. Population will continue to decline as efficiency in this industry continues to increase. The proposed project will doubtlessly add to the stability of the agricultural economy and add a recreation potential.

VII. WATER QUALITY CONTROL

Municipal, Industrial, and Agricultural Pollution

Considering the entire Musselshell River Basin which is sparsely populated, the municipal and industrial sources of pollution in the basin are limited. The following is a list of the municipal sources of waste:

TABLE XI*

Municipal Waste Sources

Town	Pop.	Type of Treatment	Discharges to	PE[a] of Effluent
Melstone	266	Lagoon	Musselshell River	Unknown
Roundup	2,842	Lagoon	Musselshell River	Not Overflowing
Harlowton	1,734	Lagoon	Musselshell River	200
Ryegate	314	Individual Systems	Subsurface	-
Lavina[b]	214	2-Story Imhoff	Musselshell River	80
Winnett[b]	360	Septic-tank	McDonald Creek[c]	270

a/ Population equivalent.
b/ Lavina & Winnett have been requested to provide lagoon treatment.
c/ McDonald Creek ultimately drains to Flatwillow Creek.

*Sources of Data: Reference 14 & 26.

The only industrial waste source in the study area which could effect project water is the oil field wastes from the oil wells along Cat Creek. However, at the present time, there is no evidence that wastes from this field are entering the Musselshell River or is there evidence available that groundwater pollution has occurred as a result of this industry.

Pollution* due to irrigation return flows is the biggest potential contributor to water quality deterioration in the Lower Musselshell River. Water quality data for the Musselshell River just above the mouth of Flatwillow Creek shows a water of varying chemical quality. Concentrations of TDS vary from 391 mg/l to 3,200 mg/l for October through April and from 640 to 1,600 mg/l for May through September. The flow weighted mean for the period of record is 1,010 mg/l (TABLE II). Data for Flatwillow Creek at the proposed damsite shows a variation in TDS concentrations from 640 - 4,180 mg/l for October through April and from 775 - 3,710 mg/l for May through September. The flow weighted mean for the period of record is 1,180 mg/l.

The flow weighted mean TDS values given above would indicate a water of acceptable quality for the proposed uses--that of irrigating feed crops such as alfalfa, oats, barley, etc. However, Table XII shows the expected effects on water quality and quantity during the irrigation season as a result of reservoir construction. This table was prepared by using the available water quality and corresponding flow data for Flatwillow Creek for the period March 11, 1964 - September 30, 1965; from this it was possible to establish a general flow vs. TDS concentration relationship. TDS concentrations were then assigned to all the monthly historic flows in Flatwillow Creek (2) for the period May, 1927 through September, 1961. May, 1927 was chosen because it represented a month when the inflow to Flatwillow Creek Reservoir would have been sufficient to almost completely displace the reservoir contents. Assuming that the quality of the outflow for any month was equal to quality of the reservoir contents at the end of the preceeding month (e.g. the June release would be same quality as the reservoir at the end of May), and that the monthly inflows are completely mixed with the reservoir contents by the end of the month plus taking into account the evaporation from the reservoir surface, it was then possible to obtain the high, low, and mean TDS concentrations of reservoir releases. Water quality and corresponding flow data for the Musselshell River above Flatwillow Creek was utilized in a manner similar to the above to assign TDS values to flow in the Musselshell River above Flatwillow Creek for the period October, 1928 - September, 1932, October, 1933 - September, 1961. Historic flows at this location were calculated by subtracting the historic

* Water is said to be polluted when its character is changed by the addition of materials, or in any other manner, in such a way that the usefulness of the water is reduced (22).

TABLE XII

Effects of Reservoir Construction on Water Quantity and Flows in the Musselshell River just Below Flatwillow Creek

Time Period	Range	Flatwillow Creek Before Project Construction Flows[c] cfs	Flatwillow Creek Before Project Construction Flows[c] 1000 AF	Flatwillow Creek Before Project Construction TDS mg/l	Flatwillow Creek Reservoir Releases Flows[c] cfs	Flatwillow Creek Reservoir Releases Flows[c] 1000 AF	Flatwillow Creek Reservoir Releases TDS mg/l	Musselshell River Below Flatwillow Creek Before Project Flows[c] cfs	Musselshell River Below Flatwillow Creek Before Project Flows[c] 1000 AF	Musselshell River Below Flatwillow Creek Before Project TDS mg/l	Musselshell River Below Flatwillow Creek After Project Flows[c] cfs	Musselshell River Below Flatwillow Creek After Project Flows[c] 1000 AF	Musselshell River Below Flatwillow Creek After Project TDS mg/l	Percent of Time that TDS in the Musselshell River is Less than or Equal to: 1000 mg/l	1500 mg/l	2000 mg/l
May	Max	1090	67.1	3000	1081	66.4	2470	1504	92.3	2590	1292	79.3	2500			
	Min	0	0	775	0	0	820	0	0	820	12	0.8	750			
	Mean[b]	48	2.9	2000	41	2.5	1810	365	22.4	1130	360	22.1	950	35.4	61.3	83.9
June	Max	1011	60.0	3000	1000	59.5	2490	3363	199.8	2600	3351	199.0	2500			
	Min	0	0.1	775	0	0	780	1.9	0.1	670	93	5.5	680			
	Mean[b]	148	8.8	1500	118	7.0	1760	940	55.8	840	910	54.1	860	56.3	71.9	96.9
July	Max	266	16.3	3400	200	12.3	2520	1514	93.0	2900	1496	99.9	2520			
	Min	0	0	1300	0	0	780	0	0	750	17	1.0	730			
	Mean[b]	41	2.5	2100	89	5.5	1800	270	16.6	990	315	19.3	1120	31.3	56.3	84.4
August	Max	41	2.5	3400	119	7.3	2515	311	19.1	2600	295	18.1	2500			
	Min	0	0	2050	0	0	890	0	0	1120	0	0	880			
	Mean[b]	4	0.3	2500	48	2.9	1780	85	5.2	1470	130	8.0	1480	6.3	36.4	71.9
September	Max	51	3.1	3400	57	3.4	2360	279	16.6	2900	279	16.6	2400			
	Min	0	0	1600	0	0	940	0	0	980	0	0	980			
	Mean[b]	3	0.2	2600	20	1.2	1860	60	3.6	1640	80	4.8	1500	6.3	21.9	71.9
[a]/Irrigation Season	Max	473	149.0	3100	239	72.4	2000	1165	352.9	2800	1100	333.8	2500			
	Min	0	0	860	0	0	800	8	2.4	790	64	19.5	700			
	Mean[b]	49	14.7	1730	63	19.1	1800	340	103.0	990	360	109.0	1000	39[d]	71[d]	90[d]

[a]/ The range of values given for the irrigation season pertain to the maximum average flow, minimum average flow and the mean flow for the irrigation season May through September. The maximums and minimums are for the year of the period of record they occurred, i e. although high maximums are given May, June, and July, they did not occur the same year.

[b]/ The mean values given are time-weighted for flow and flow weighted for TDS concentration.

[c]/ The maximum and minimum values given are for the entire period of record available: for Flatwillow Creek this is October 1925- September 1961, for the Musselshell River this is October 1928 - September 1932, October 1933 - September 1961.

[d]/ This says that the flow-weighted mean value for an irrigation season will be equal to or less than 1000 mg/l 39% of the time, equal to or less than 1500 mg/l 71% of the time, and equal to or less than 2000 mg/l 90% of the time.

monthly flows for Flatwillow Creek from the historic monthly flows of the Musselshell River below the Flatwillow Creek confluence. Having calculated the TDS concentrations of Flatwillow Creek inflows and outflows and the TDS concentrations of the historic flows in the Musselshell River above Flatwillow Creek it was then possible to determine the TDS concentrations of the Musselshell River just below Flatwillow Creek before and after project construction.

Table XII shows that the construction of Flatwillow Reservoir smooths out the TDS concentrations of the average monthly releases for the period of record. The average TDS concentration of reservoir releases during the irrigation season for the period of record increases from 1,730 to 1,800 mg/l; only a slight increase is noted in the flow weighted mean TDS concentration from 990 to 1,000 mg/l of the Musselshell River just below Flatwillow Creek during the irrigation season. The righthand columns on this table show the percentage of time over the period of record (31 years) that a certain TDS concentration will occur. For example, 35.4% of the time, themonthly TDS concentrations in the Musselshell River just below Flatwillow Creek for May will be 1,000 mg/l or less; 61.3% the concentrations will be 1,500 mg/l or less and 83.9% of the time the concentration will be 2,000 mg/l or less. For the entire irrigation season, 39% of the time the flow weighted mean TDS will be 1,000 mg/l or less, 71% of the time it will be 1,500 mg/l or less, and 90% of the time it will be 2,000 mg/l or less.

There are no data available on the quantity or quality of flows in the Musselshell River below Mosby. Although the total amount of irrigation water needed each season is known, the monthly application of this water from May through Setpember is not. In general, the maximum demands are made on project water during years of low flow when the effective precipitation is least and, conversely, the minimum demands are made when the effective precipitation is greatest; however, when more than one year of low runoff occurs in succession, there will not be sufficient water to irrigate all 8,000 acres. The average yearly irrigation demand is approximately 24,000 acre feet.

On the basis of a similiar project (27), it is assumed that about 40% of the applied water returns to the river over a period of a year and that 65% of this total return flow occurs in May through September. Also, for this project, it was assumed that if a 1:1 salt balance was maintained, that 65% of the salt load was returned during irrigation season and if a 1 ton per acre per year of extra salt was leached out it was assumed that 0.65 ton acre was returned during irrigation season. When any salt pickup was assumed--the entire 8,000 acres was considered to be irrigated although this will not necessarily be the case in low flow years. If the accretions other than irrigation returns to the Musselshell River in the 30 mile reach of river

TABLE XIII

Estimated Effects on Water Quality and Flows at the Downstream End of the Lower Musselshell Unit[a/]

Musselshell River Just Below Flatwillow Creek Confluence		Irrigation Demands	Irrigation[c/] Returns	Musselshell River at Lower End of Project			
Flows 1000 A-F	TDS mg/l	1000 A-F	1000 A-F	Flows 1000 A-F	TDS (Assuming a 1:1 Salt Balance)	TDS[d/] (Assuming 1 ton/acre per year of extra salt picked up)	TDS (Assuming 2 ton/acre per year of extra salt picked up)
333.0 **(Max.)**	860 **(Min.)**	14.8	3.8	322	880	890	900
19.5 **(Min.)**	2500 **(Max.)**	17.7[b/]	4.6	6.4	5200	5800	6400
109.0 (Mean)	1000 (Mean)	24.0 (Mean)	6.2	91.2	1100	1150	1190

a/ For the irrigation season only

b/ The year 1961 of the Bureau of Reclamation operation study. The worst condition presented was the year 1961 of the Bureau of Reclamation operation study. The actual irrigation demand was 25,700 acre-feet, however, there was a 8,000 acre-feet shortage.

c/ Irrigation return flow during irrigation season = (0.65)(0.40) x irrigation demand.

d/ Assume there is a salt pickup of one ton per irrigated acre per year and that 65% of it is picked up during irrigation season, also assume that all 8,000 acres are irrigated each year.

below Flatwillow are neglected, it is possible, using the foregoing assumptions, to estimate the maximum, minimum, and average conditions at the downstream end of the unit during irrigation season. Table XIII shows the estimated effects of the Lower Musselshell Unit on water quality and flows in the lower reaches of the Musselshell River.

Water Quality Criteria

The water quality criteria considered in this project were dissolved oxygen and dissolved minerals. Dissolved oxygen represents the ability of a stream to assimilate organic material and sustain fish and other aquatic life. Generally, a minimum dissolved oxygen content of 4 mg/l is adequate for the warm water fish found in this portion of the Musselshell River.

The main use of project water will be irrigation. The suitability of water for this use is partially dependent on the concentrations of dissolved minerals. Individual mineral constituents such as boron and chloride can have detrimental effects on plants if present in sufficient concentrations. The relative concentration of sodium to that of calcium and magnesium (sodium absorption ratio) is important when water is used to irrigate clayey soils. If the proportion of sodium to calcium and mganesium is high, the alkali hazard is high; if calcium and magnesium predominate, the alkali hazard is low. Richards (15) would class the waters of the Musselshell River and Flatwillow Creek as having a low alkali hazard (SAR: 0-10) and a high to very high salinity hazard (Conductivity: 750-5,000 umhos). The critical concentrations of TDS for irrigation water are dependent on many factors such as the types of crops being irrigated, the type of soil, the type irrigation method used, the amount of water applied, and the method of soil preparation. Water with a salt concentration up to 2,150 mg/l is considered suitable for the type of crops that will be grown here. Generally, 3,150 mg/l is considered the upper limit for the safe watering of any plants if adequate leaching and drainage are provided (15) (24).

Flow Regulations

This study revealed no apparent sources of organic pollution nor any evidence of a deficiency in dissolved oxygen in the river. The Bureau of Sport Fisheries and Wildlife (23) has stated that the Musselshell River at Mosby presently provides good fishing when flows are favorable. Since there is an absence of organic pollution at present and the unlikelihood of any future organic waste loadings in the study area it is concluded that this project will not cause any dissolved oxygen problems under the conditions anticipated in the Musselshell River.

The effects of the project on water quality for average conditions would be negligible under the assumptions set forth for Table XIII. The water quality at the lower end of the project has a TDS concentration under average conditions which is less than the TDS of Flatwillow Reservoir releases. However, under low flow conditions, TDS concentrations are expected to exceed 3,150 mg/l in the downstream portions of the project area[a/]. Based on historical records, it is anticipated that this condition would occur with a frequency of 6-8 times in 31 years, depending on the low flow condition and the salt pickup; i.e., if a 1:1 salt balance is maintained, the value 3,150 mg/l is exceeded 6 times and if 2 tons per acre per year extra salt are picked up it is exceeded 8 times. About 4-6 additional years the average TDS concentration will exceed 2,150 mg/l but will be less than 3,150 mg/l depending on the conditions as described above. It would require about 10,000 acre-feet[b/] of additional water during an irrigation season to maintain an average TDS concentration no greater than 3,150 mg/l in the lower reaches of the project if the TDS concentrations of the reservoir releases were no greater than 1,900 mg/l. When the quality of the reservoir release exceeds 1,900 mg/l more water would be required. For example, referring to the worst condition given in Table XIII for a 1:1 salt balance, about 10,000 acre-feet of water is required if the water quality is 1,900 mg/l; however, since this is the worst year during the period of record, the water quality of the reservoir release would be about 2,500 mg/l. This would require about 20,000 acre-feet of water for quality control.

During years of high runoff excess water would be available for storage for subsequent use in water quality control. With as many as 4 critical years occurring between periods of high runoff, it would be necessary to have a total draft on storage of about 40,000 acre-feet in order to meet water quality control requirements.

An alternative to water quality control would be to reduce the amount of acreage under irrigation during the critical years. This would allow the available water to be applied in adequate amounts to insure proper leaching of the remaining land. It is recommended that this alternative be used; also only the more salt tolerant crops (i.e., alfalfa, oats, barley, etc.) should be grown and adequate drainage should be provided for irrigated fields.

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a/ This could be detrimental to the irrigators along the lower reaches of the project.

b/ Ten thousand acre-feet of storage would be required for 6 years if a 1:1 salt balance is maintained and for 8 years if there is a pickup of 2 tons/acre extra salt per year.

The average monthly flows of the Musselshell River at Mosby for the period of record, generally, constitute less than 0.2 percent of the average monthly contents of Fort Peck Reservoir. Therefore, the flow depletions and salt accretions in the Musselshell River will have only negligible effects on water quality in the Missouri River. Since regulation of flows from Flatwillow Reservoir cannot effect the quality of the Missouri River, storage for the purpose of flow regulation for the purpose of water quality control below the project has not been recommended.

The foregoing conclusions are based on the reasonable extension of results of other studies. The lack of water quality and flow data below Mosby precludes a more descriptive analysis of project effects. The results provided herein are suitable for use in determining project feasibility. The completion of the Missouri-Souris-Red River Basins Comprehensive Water Supply and Water Quality Management Study being conducted in this region by the Federal Water Pollution Control Administration may provide additional information.

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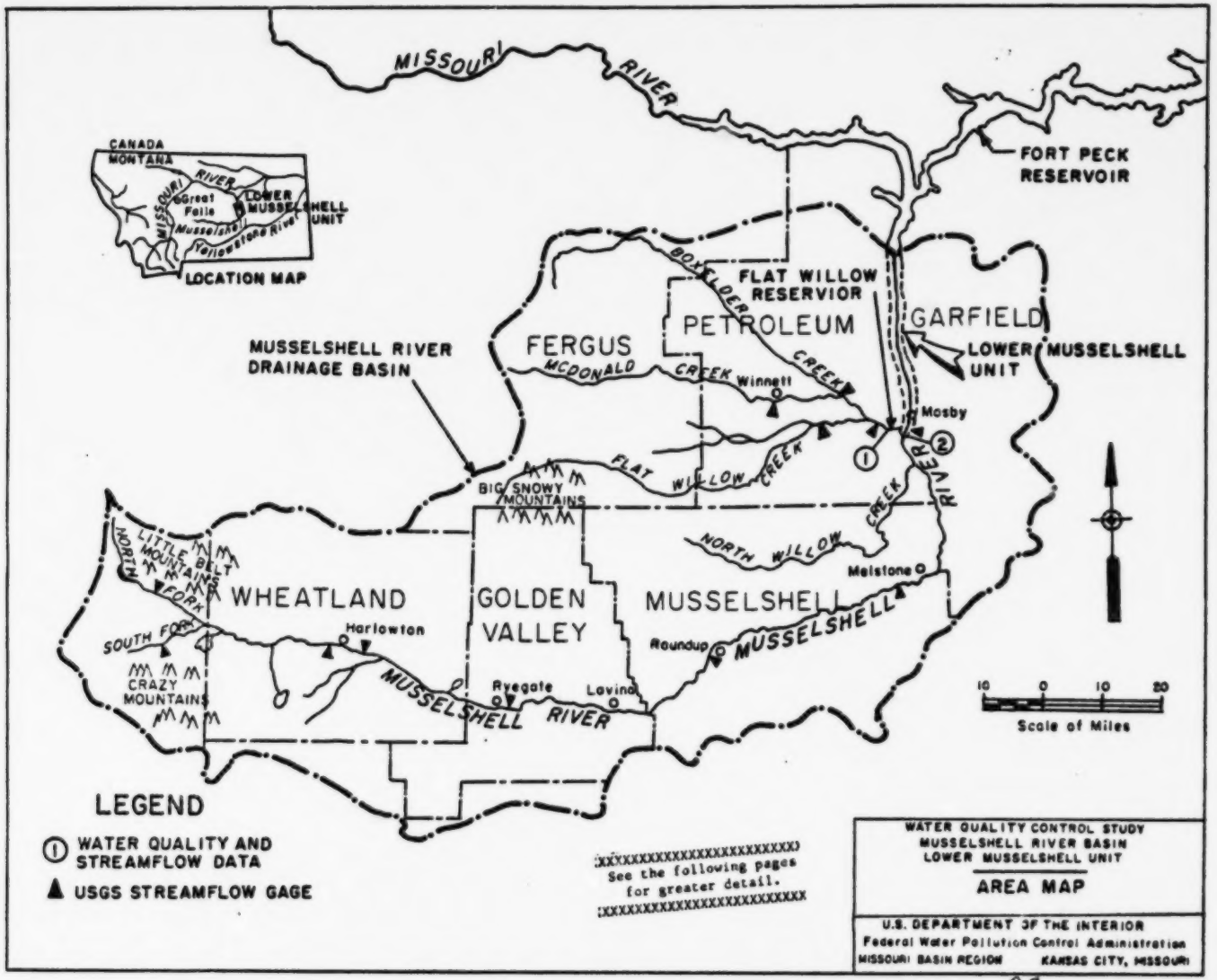
MISSOURI RIVER
FORT PECK RESERVOIR
CANADA
MONTANA
MISSOURI RIVER
Great Falls
LOWER MUSSELSHELL UNIT
Musselshell River
Yellowstone River
LOCATION MAP
BOX ELDER CREEK
FLAT WILLOW RESERVOIR
PETROLEUM
GARFIELD
FERGUS
LOWER MUSSELSHELL UNIT
MUSSELSHELL RIVER DRAINAGE BASIN
McDONALD CREEK
Winnett
Mosby
RIVER
FLAT WILLOW CREEK
BIG SNOWY MOUNTAINS
NORTH WILLOW CREEK
Melstone
NORTH FORK
LITTLE BELT MOUNTAINS
WHEATLAND
GOLDEN VALLEY
MUSSELSHELL
SOUTH FORK
Harlowton
Roundup
MUSSELSHELL
CRAZY MOUNTAINS
Ryegate
Lavina
MUSSELSHELL RIVER
10 0 10 20
Scale of Miles
LEGEND
① WATER QUALITY AND STREAMFLOW DATA
▲ USGS STREAMFLOW GAGE
See the following pages for greater detail.
WATER QUALITY CONTROL STUDY
MUSSELSHELL RIVER BASIN
LOWER MUSSELSHELL UNIT
AREA MAP
U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
MISSOURI BASIN REGION KANSAS CITY, MISSOURI

28 FIGURE 1